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Summary of the Rapid Response to Round Goby (*Neogobius melanostomus)* in Pefferlaw Brook with an Evaluation of the National Rapid Response Framework based on the Pefferlaw Brook Experience

Sommaire de l'intervention rapide à la suite de la découverte du gobie à taches noires (*Neogobius melanostomus*) dans le ruisseau Pefferlaw et évaluation du cadre national d'intervention rapide d'après l'expérience acquise au ruisseau Pefferlaw

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ABSTRACT

Rapid response measures to combat invasive aquatic species are in place in many countries but a formal rapid response procedure is not yet in place in Canada.

An *ad hoc* rapid response to Round Goby (*Neogobius melanostomus*) in Pefferlaw Brook was initiated in the summer of 2004. Pefferlaw Brook is a tributary of Lake Simcoe and there was concern about the potential impact of Round Goby to the lucrative sports fishery and aquatic resources of the lake. After consideration of available management options, an experimental chemical piscicide treatment was carried out in the fall of 2005.

Post-treatment assessment found that the rapid response to the presence of Round Goby in Pefferlaw Brook was not successful in eradicating Round Goby from the brook, or preventing its spread into Lake Simcoe, however partial mitigation was achieved as the rate of spread was greatly reduced. Post-treatment sampling of fish assemblages of Pefferlaw Brook indicated a successful recovery of fishes. Valuable experience was gained that will enhance rapid response planning and implementation as well as the management of Round Goby in other waters.

Key partners in the undertaking were the Ontario Ministry of Natural Resources, Ontario Federation of Anglers and Hunters, and the Department of Fisheries and Oceans, along with the involvement of other governmental agencies and community groups.

This report is presented in two parts. The first part provides a comprehensive summary of the Pefferlaw Brook rapid response. The second part evaluates the proposed draft national framework for rapid response management in the context of the Pefferlaw Brook experience. Recommendations are provided for the draft framework.

RÉSUMÉ

De nombreux pays ont mis en place des mesures d'intervention rapide pour lutter contre les espèces aquatiques envahissantes, mais aucun processus d'intervention rapide officiel n'existe au Canada.

À l'été 2004, on a déclenché une intervention rapide à la suite de la découverte du gobie à taches noires (*Neogobius melanostomus*) dans le ruisseau Pefferlaw. Ce ruisseau est un tributaire du lac Simcoe, et on était préoccupé par l'impact que pouvait avoir le gobie à taches noires sur la lucrative pêche sportive et sur les ressources aquatiques du lac. Après avoir pris en considération les options de gestion disponibles, on a procédé à un traitement expérimental avec un piscicide chimique à l'automne 2005.

Selon l'évaluation menée après le traitement, l'intervention rapide déclenchée à la suite de la découverte du gobie à taches noires dans le ruisseau Pefferlaw n'a pas été couronnée de succès, puisqu'elle n'a pas permis d'éradiquer le gobie du ruisseau ni d'empêcher sa propagation dans le lac Simcoe; il convient toutefois de préciser que l'on a atténué en partie la menace puisque le taux de propagation a décliné de façon importante. L'échantillonnage post-traitement des assemblages de poissons du ruisseau Pefferlaw indique le succès du rétablissement des poissons. On a acquis une expérience précieuse qui améliorera la planification et la mise en œuvre d'interventions rapides ainsi que la gestion du gobie à taches noires dans d'autres plans d'eau.

Le ministère des Richesses naturelles de l'Ontario, la Ontario Federation of Anglers and Hunters, le ministère des Pêches et des Océans sont les partenaires clés de cette initiative à laquelle d'autres agences gouvernementales et collectivités ont pris part.

Le présent rapport est divisé en deux parties. La première partie présente un sommaire global de l'intervention rapide menée dans le ruisseau Pefferlaw. La deuxième partie évalue l'ébauche du cadre national proposé pour la gestion des interventions rapides dans le contexte de l'expérience acquise au ruisseau Pefferlaw. Des recommandations sont formulées pour l'ébauche du cadre.

INTRODUCTION

Rapid response is a management approach developed to prevent the spread of invasive species. It is a series of steps, which ideally start before the detection of a non-indigenous species, intended to prevent colonization by the unwanted species. The goal is almost always eradication of the target species (Locke and Hanson 2009a). In aquatic systems, eradication may not always be possible and assessment is required to determine which goals are attainable (WANS 2003). Rapid response measures to combat aquatic invasive species are in place in many countries and, although a formal procedure is not yet in place in Canada, rapid response has been an important management approach in Atlantic Canada for managing marine invasive species. Currently, a national framework has been proposed that can be used to develop rapid response plans for use in all Canadian waters (Locke and Hanson 2009b). The Ontario Biodiversity Strategy (OMNR 2005a) and the Canadian National Aquatic Invasive Species Plan (DFO 2008) identify the need to build capacity for rapidly detecting and responding to invasive species through management and eradication.

An *ad hoc* rapid response to Round Goby in Pefferlaw Brook was initiated in the summer of 2004. Round goby, an invasive fish species known to be detrimental to native fish populations (Corkum 2004; Cudmore and Koops 2007), was discovered in Pefferlaw Brook in August, 2004. Pefferlaw Brook is a tributary of Lake Simcoe and there was fear that this species would move into the lake, putting the lucrative sportsfish industry of Lake Simcoe at risk. Invasive species were identified in the State of Lake Simcoe Watershed Report (LSEMS 2003) as a major threat to the biodiversity and stability of the Lake Simcoe ecosystem. The Ontario Ministry of Natural Resources (OMNR), in partnership with the Ontario Federation of Anglers and Hunters (OFAH), identified as a high priority the prevention of Round Goby from entering Lake Simcoe. After consideration of available management options, a one time application experimental chemical piscicide treatment was carried out in October, 2005 to eliminate Round Goby from Pefferlaw Brook. Key partners in the undertaking were the Ontario Ministry of Natural Resources, Ontario Federation of Anglers and Hunters, and the Department of Fisheries and Oceans, along with the involvement of other governmental agencies and community groups. The eradication of Round Goby from Pefferlaw Brook was undertaken as part of an ongoing provincial research initiative to study the behaviour, management, and control of this invasive species (OMNR 2005b).

Subsequent to the treatment, small numbers of Round Goby were detected in the spring of 2006 in Pefferlaw Brook but the numbers were drastically reduced. However, with the discovery in July 2006, of one Round Goby in Lake Simcoe at the mouth of Pefferlaw Brook, OMNR and its partners concluded that, given the one time piscicide application restriction, it was no longer possible to eradicate Round Goby from the Lake Simcoe watershed (OMNR 2006). Further eradication attempts were abandoned, a decision reached during the planning stages, should Round Goby be discovered in the lake.

This report is presented in two parts. The first part provides a comprehensive summary of the rapid response steps taken in the Pefferlaw Brook Round Goby Eradication Project, including the rationale for each step and all regulatory considerations. The second part evaluates the draft national framework for rapid response based on the Pefferlaw Brook experience.

PART 1. SUMMARY OF THE STEPS TAKEN IN THE RAPID RESPONSE TO ROUND GOBY IN PEFFERLAW BROOK

1.1.0. BACKGROUND

1.1.1. DISTRIBUTION AND IMPACT OF ROUND GOBY

1.1.1.1. Distribution

Round Goby (*Neogobius melanostomus*) is a small benthic fish, native to the Ponto-Caspian region. First discovered in Lake St. Clair in 1990, it has spread rapidly through the Great Lakes and St. Lawrence River basins, likely transported from Eurasia through ballast water (Corkum *et al.* 2004). It has been found in Lake St. Clair, the Detroit River, all of the Great Lakes, and the St. Lawrence River basin. Recently it has been found inland in Ontario in the Trent-Severn Waterway, Rice Lake, Pefferlaw Brook, and Lake Simcoe (OFAH 2009) (Figure 1).

Figure 1. Distribution of Round Goby in Ontario

1.1.1.2. Impact

Although it has been in the Great Lakes for a relatively short period of time, and the extent of its effect is not yet known, there is already cause for concern. Corkum *et al.* (2004) noted the following:

- Round Goby proliferates rapidly as it is a multiple spawner, and spawns repeatedly throughout the spring, summer, and fall.
- It is tolerant of a wide range of environmental factors.
- As it feeds predominately on benthic organisms exposed to contaminated sediments, including Zebra Mussels (*Dreissena polymorpha)*, it transfers contaminants through the food web as it is, in turn, preyed upon by sport and commercial fishes, becoming a human health concern.
- A decline in the abundance of Mottled Sculpin (*Cottus bairdii)* and Logperch (*Percina caprodes)* in the St. Clair River coincided with the proliferation of Round Goby, possibly a result of spawning interference or displacement of the native species from their habitat by the aggressive goby.
- Round Goby has been observed, both in the lab and in the field, to feed on the eggs of native fish species, including Lake Trout (*Salvelinus namaycush)* and Lake Sturgeon (*Acipenser fulvescens)*. This has a negative effect on recruitment of native fishes.
- A link between Round Goby and botulism E., a disease of migratory birds, has been suggested but needs more research. The toxin may be ingested by Round Goby feeding on infected zebra mussels, then transferred to the piscivorous fishes and birds which prey upon Round Goby.

1.1.2. PEFFERLAW BROOK

1.1.2.1. General Description

Pefferlaw Brook is a tributary of Lake Simcoe. It is a small watershed located approximately 2 km southwest of Port Bolster and drains into Lake Simcoe on its southeastern side. Pefferlaw Brook originates about 8.5 km south of Lake Simcoe where it joins with Uxbridge Brook (Greenland International 2005). A map of the subwatersheds of Lake Simcoe is provided in Appendix 1. There is a dam on Pefferlaw Brook approximately 5 km upstream from Lake Simcoe and there are breakwalls on either side of the mouth where it enters the lake.

Lower Pefferlaw Brook is primarily home to warm-water fish species. It also provides habitat and possible spawning areas for some of the warm- and cold-water game and panfish species found in Lake Simcoe (Greenland International 2005). A list of fish species found in Pefferlaw Brook below the dam, pre- and post-treatment, is provided in Appendix 2. No known fish species or aquatic invertebrates at risk were present in Pefferlaw Brook at the time of the study.

1.1.2.2. Study Site

In August of 2004, a Round Goby was angled approximately 3.4 km upstream of Lake Simcoe. The vector of infection was suspected to be associated with the live bait trade (Cudmore and Koops 2007). Monitoring activities up to the time of treatment in the fall of 2005 indicated that the infestation was confined to a 5 km stretch of Pefferlaw Brook (Cudmore and Koops 2007). No Round Goby were found above the dam, an effective barrier to upstream movement of fishes (Greenland International 2005). The proposed study site encompassed everything from

the dam downstream to, and including, the breakwalls. Figure 2 provides a map of the study area.

The area immediately below the dam is relatively narrow, while the section downstream of the bridge on Hwy 48 has numerous backwaters to allow boat access from homes off the main channel, marinas with extensive channels and docking facilities, and a major, forked tributary near the mouth of the brook on the east side. The breakwalls are extensive, extending 500-600 m out into the lake and offer the only goby habitat at the mouth of the brook. Commercial uses in the area include several marinas, resorts and bait operations (Borwick 2005).

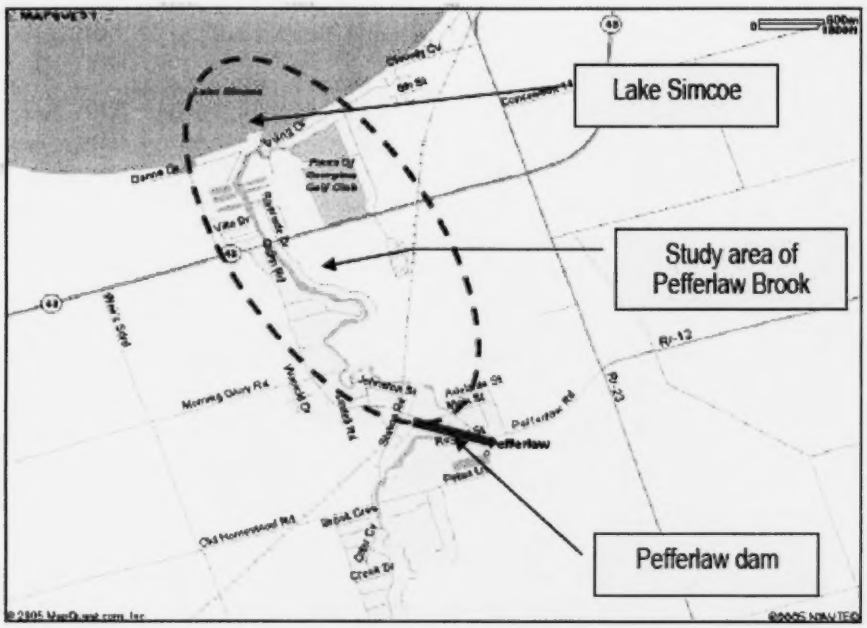

Figure 2. Study site for Pefferlaw Brook Round Goby eradication project

1.2.0. THE RAPID RESPONSE

1.2.1. CONTEXT

The steps taken in the rapid response to Round Goby in Pefferlaw Brook are presented in the following section, in roughly chronological order. Although the proposed framework did not exist at the time, in order to assist with the evaluation of the framework in Section 2 of this report, an attempt has been made to organize the Pefferlaw actions to correspond to the phases outlined in the post-invasion process of the national draft framework. Six phases are identified in the post-invasion process of the framework (Locke and Hanson 2009b):

- Detection Phase
- Demarkation Phase
- Containment Phase
- Risk Assessment Phase
- Implementation Phase

- Follow-up Phase

The proposed framework has been provided as a checklist in Appendix 3.

1.2.2. **DETECTION PHASE** (summer 2004 - fall 2004)

In early August of 2004, the first Round Goby in Pefferlaw Brook was reported to the Invading Species Hotline. The Invading Species Hotline is part of the Invading Species Awareness Program developed in 1992 by the OFAH, in partnership with OMNR, to address the threats from nonnative invading species. The fish was caught by an angler approximately 3.8 km upstream of Lake Simcoe. The identity of the fish was initially confirmed by staff at the Lake Simcoe Fisheries Assessment Unit (LSFAU) and, within days, confirmed by staff at the Royal Ontario Museum. Given the known severe impact Round Goby has on native fish populations and biodiversity, it was decided that action was urgently required to prevent this species from entering Lake Simcoe. OMNR, OFAH, and Fisheries and Oceans Canada (DFO) were the primary agencies responsible for executing the rapid response, with OMNR taking the lead.

Immediately, in the fall of 2004, an intensive public awareness campaign was mounted by OMNR, OFAH, and local angling groups to inform the public of the urgency of the situation and to solicit support in reporting sightings of Round Goby. An outreach campaign was initiated, including door-to-door canvassing of residents, marinas, tackle shops, and sending over 300 mail-outs to resorts, marinas, bait operators and licence issuers. Warning signs were posted at all public access and fishing areas (Greenland International 2005). Objectives of the public awareness campaign included: raise awareness of invasive species in general, and of Round Goby in Pefferlaw Brook in particular; gain support for the initiative to eradicate Round Goby from Pefferlaw Brook; enlist help in monitoring the distribution of Round Goby; and, curb further spread by live bait transfer.

1.2.3. **DEMARKATION PHASE** (fall 2004 - spring 2005)

A cooperative surveillance program (OMNR, OFAH, DFO, and LSFAU) was quickly initiated in the fall of 2004 to determine the distribution and density of Round Goby in Pefferlaw Brook, Lake Simcoe, and other tributaries of Lake Simcoe. OMNR, OFAH, and the LSFAU conducted 10 trawls in the lake, at the breakwall, and in the channel. Other sampling techniques included modified minnow traps, seine netting, electrofishing, bottom trawling, and angling. Backpack electrofishing was carried out in other subwatersheds by the Lake Simcoe Region Conservation Authority. No Round Goby were found in the other tributaries of Lake Simcoe or in Lake Simcoe. In Pefferlaw Brook, no Round Goby were captured in the mouth of the river or north of the HWY 48 bridge at that time. Bait traps were placed in the brook, in the vicinity of the discovery, and monitored daily (OMNR 2005c; Greenland International 2005).

OFAH and local angling groups played a key role in these surveillance efforts, as well as in the notification of the public and local residents of the situation and soliciting their help to report sightings of Goby (Borwick 2005).

A technical committee (OMNR, OFAH, University of Windsor, DFO, Great Lakes Fishery Commission) was convened to provide technical advice, investigate control options, and develop a sampling protocol to assess distribution and abundance of Round Goby in the brook.

In the winter of 2004, existing research on Round Goby and its management options, including permit and approval requirements, were reviewed. Background data on species composition

and abundance, flow regime, temperature data, and other environmental variables for Lake Simcoe and Pefferlaw Brook were compiled.

The communication process continued with the stakeholders, through the Invasive Species Workshop held at York University (November 7, 2004), various fishing shows, and mail-outs to ice-hut operators. Anglers were reminded that it was illegal to release baitfish from one waterbody to another and illegal to use Round Goby as bait, as it was suspected that the vector of infection was live bait.

1.2.4. **CONTAINMENT PHASE** (spring 2005 - summer 2005)

Monitoring resumed in the spring and continued with traps being customized as capture techniques improved. Data compilation and collaboration with other goby experts continued.

Communication continued with stakeholders and information packages were sent to baitfish retailers and harvesters to ensure the infestation was not spread or intensified. The Goby Fishing Derby (June 5, 2005) was held as a cooperative event among many partners – contributing to monitoring while raising public awareness and helping to foster partnerships and goodwill in the community.

OMNR sought, and was granted, internal approval to proceed with the experimental research proposed for Pefferlaw Brook. OMNR , under the *Environmental Assessment Act,* Reg. 334, s. 11 is provided an exemption to conduct research projects (i.e., measuring, monitoring, and testing). This exemption provided OMNR with the appropriate *EA Act* coverage to allow the research project to proceed.

The research project was undertaken as a collaborative initiative between OMNR, OFAH, University of Windsor, and DFO, in May of 2005. The research plan was drafted with the following study objectives (OMNR 2005c, DFO 2005):

- assess the current distribution of Round Goby in Pefferlaw Brook;
- evaluate gear selectivity for Round Goby detection within wadeable and non-wadeable habitats within Pefferlaw Brook and within a paired stream in the Lake Erie drainage;
- if chemical eradication of Round Goby in Pefferlaw Brook occurs, evaluate the effectiveness of chemical eradication as a rapid response action including the impact on the benthic and fish communities, and the recolonization of the site;
- build multi-agency collaborative capacity and best management practices for invasive species management; and,
- raise awareness about the problems associated with invasive species and the importance of preventing further introductions.

Accordingly, DFO initiated a survey of the Pefferlaw Brook fish communities in the spring of 2005. Sampling was carried out from May 17 to November 15, 2005, and May to October, 2006. Pre-and post-treatment data were gathered to evaluate the recovery of the fish communities following rotenone treatment (Marson and Mandrak 2009).

As part of this research project, a gear calibration experiment was carried out May 16-19, 2005. Sites were selected in the vicinity of the initial capture site to determine the distribution of Round Goby, particularly downstream of the site, as well as to evaluate the effectiveness of the gear. The results of this study were used to determine gear type and effort to be used for the pre-

treatment and post-treatment monitoring as well as for the translocation to Lake Simcoe of all fishes possible, except Round Goby, the week before the chemical treatment (DFO 2005). Given the potentially devastating impact to Lake Simcoe fish populations, biodiversity and the sportfishing industry, the preferred outcome of the management option was the eradication of Round Goby from Pefferlaw Brook. The decision to eradicate was based on:

- current density and distribution data indicated the infestation was small;
- infected area was well defined;
- appeared to be a will to act;
- serious negative impact of Round Goby well established elsewhere; and,
- stakes were high with the multi-million dollar sport fishery of Lake Simcoe at risk.

It was decided that there was a high likelihood of success in the complete removal of Round Goby from the affected area of Pefferlaw Brook (OMNR 2005c), if action was taken promptly. In the spring of 2005, a consultant was retained to determine options for removing Round Goby from Pefferlaw Brook.

Monitoring was intensified during the summer of 2005 and Round Goby began to be detected further downstream of the Hwy 48 bridge (August 19, 2005), and at the breakwall (August 30, 2005) (Borwick 2005; Marson and Mandrak 2009). In response, silt curtains were erected at the breakwalls as a temporary containment measure to prevent the infestation of Lake Simcoe (Sept. 12-22, 2009).

1.2.5. **RISK ASSESSMENT PHASE** (summer 2005-fall 2005)

As a risk assessment was not undertaken prior to the rapid response, the risk assessment component of this phase is not applicable to this project. Control options is the only applicable component of this phase.

Control Options

The management options that were considered are presented in Table 1.

Table 1. Control options considered for control of Round Goby in Pefferlaw Brook

Option	Pros	Cons
Physical Removal - angling, trapping, netting, electrofishing, etc.	• selective for Round Goby • environmentally friendly	• slow, inefficient, labour intensive and expensive • will not achieve complete eradication
Physical Control - research underway to assess effectiveness of customized traps baited with goby pheromones or sound recordings of reproductive goby	• selective for Round Goby • environmentally friendly	• still in research phase, not yet ready for field application • labour intensive • difficult to attain eradication of target species
Fish Barriers and Acoustic/Vibration Barriers	• environmentally friendly	• not suited to Pefferlaw Brook • time consuming • does not eradicate target species • expensive • disruptive to recreational activities
Dewatering and Water Fluctuation Techniques	• may be low cost • can achieve complete eradication	• not species specific, environmentally very disruptive • water may remain in some sections • not suitable for Pefferlaw given the extensive backwater conditions in the lower sections
Chemical Control - use of a piscicide (rotenone)	• proven technique • results are immediate • moderate cost • targets only gill-breathing organisms • non toxic for humans if applied properly	• not species specific • public perception and health and safety concerns • not suitable for all sites • appropriate for Pefferlaw Brook as it is a contained site
Biological Control - there is currently no known control agent for Round Goby	• could be selective to Round Goby • moderate cost	• manages but does not eradicate a species • rigorous screening before control agent can be released • no known control agent for Round Goby
Combined Treatment - use of limited chemical treatment with physical options such as the baited traps mentioned above or manufactured floating vegetation mats	• reduced use of piscicide • moderate cost	• still in research phase- not ready for Pefferlaw Brook • may pose obstacles to boat traffic • promising technique that requires further research
No Action	• no cost/time/effort expenditure	• Round Goby will spread to Lake Simcoe with a probable profound impact on native fish, lake biodiversity and sport fishing industry

Sources: OMNR 2005c; Greenland International 2005

After consideration of the control options provided by the consultant, the preferred management option was selected: to apply a piscicide to completely eradicate Round Goby from Pefferlaw Brook. The rationale for the selection of a piscicide, specifically rotenone, was (OMNR 2005b; OMNR 2005d; Greenland International 2005):

- most effective way to completely eradicate an undesirable fish population from the affected area;

- other options were experimental, not effective, or too time consuming to implement;
- can be implemented relatively quickly (in the case of Pefferlaw Brook it is critical to act quickly);
- rotenone is effective against Round Goby at concentrations allowable for use in Canada;
- (temporary) loss of non-target species is deemed acceptable given the threat to Lake Simcoe;
- literature review revealed no other method currently exists for managing goby populations;
- application of rotenone is a proven method having been used extensively in North America for fisheries management and by OMNR in Ontario;
- rotenone affects only gill-breathing organisms;
- rotenone does not bioaccumulate in the aquatic environment, degrades in a matter of hours;
- no apparent harm to birds, wildlife, or humans; and,
- commonly used in agriculture.

1.2.6. **IMPLEMENTATION PHASE** (summer 2005-fall 2005)

1.2.6.1. Prior to Treatment

A schedule was set for implementation. Based on calculations of flow, water temperature, and water levels, the consultant advised that mid-October would be the best time to carry out the eradication program. The following considerations were taken into account:

- Action is needed as soon as possible to ensure Round Goby do not spread to Lake Simcoe.
- The procedure requires low lake levels, but sufficient flow in the brook to distribute the chemicals (OMNR 2005b).
- Round Goby are multiple spawners. The water temperature must therefore be low enough to ensure that spawning has ceased and all eggs have hatched (rotenone does not affect the fish eggs) (OMNR 2005b).
- The water temperature must not be too cool as Round Goby burrow into the stream bed when water temperatures fall, where they are not as susceptible to treatment.
- The stream flows and water temperatures of Pefferlaw Brook were found to be suitable for this type of treatment.
- Lake levels, stream flows, water temperature, wind direction, and the weather forecast will be monitored prior to, and during, the procedure.
- Impacts to Emerald Shiner (*Notropis atherinoides*) and Yellow Perch (*Perca flavescens*) that migrate into the brook in the fall had to be considered.
- Monitoring will continue right up until the day of the proposed treatment concentrating on the detection of Round Goby in the mouth of Pefferlaw Brook and the area of Lake Simcoe adjacent to the mouth. If the monitoring detects Round Goby in Lake Simcoe, the procedure will not proceed.

The week of October 17, 2005 was selected for treatment, contingent on conditions at the time. The collection of data continued with the assembly of bathymetric and flow data. A comprehensive modeling exercise, including a hydraulic model and a chemical dispersion model, along with field measurements, was conducted by the consultant to predict and assess application requirements for rotenone. A detailed summary of these data are provided in Greenland International (2005).

OMNR initiated the external approval process for applying a piscicide, including a detailed and site-specific Health and Safety Plan. The project was described as a one-time research project to remove Round Goby from a section of Pefferlaw Brook with the information derived from project used to determine the need for longer-term *EA Act* coverage. There was no documentation or evidence of the presence of any species at risk under federal or provincial legislation. Approvals were required from:

- OMNR – project screening under *A Class Environmental Assessment for MNR Resource Stewardship and Facility Development Projects.*
- Ontario Ministry of the Environment (OMOE) - Permit was required under the *Pesticide Act* - a licensed applicator was required under this permit as one of the conditions levied. The DFO Sea Lamprey technicians were selected as the licensed applicators.
- DFO - Section 32 *Fisheries Act* (prevention of unauthorized killing of fish by means other than fishing) required a full *Canadian Environmental Assessment Act* (CEAA) review.
- Ontario Pesticides Advisory Committee (OPAC) - Reclassification of the piscicide as the classification of ChemFish as a piscicide had lapsed.
- A detailed and site-specific Health and Safety Plan was also required.

At this point, planning was underway and OMNR drafted the research project, technical implementation, and communication plans (Greenland International 2005; OMNR 2005b). Some of the key components of the communication plan included OMNR internal briefings, information sessions with the local Mayor and Councillors, and technical briefings with agencies and key stakeholders. The intent was to build support for the initiative prior to the formal announcement of the project to the public at the public meeting. Technical implementation plans included logistics, such as the non-target fish collection, staff scheduling and support during the treatment, post-treatment fish clean-up and disposal, pre- and post-treatment monitoring. Budget plans included requesting funding and in kind support from partner agencies and organizations to help offset the overall cost, but OMNR was prepared to initially front end the project cost (OMNR 2005b).

The decision to apply a piscicide was communicated to the public through a public meeting in Pefferlaw (October 4, 2005). A public awareness campaign was mounted to provide information on the chemical treatment - a notice was placed in the local paper, the public meeting was held, information packages were hand delivered, information signs were placed throughout the treatment site, and a temporary information and media centre was setup prior to, and maintained throughout, the treatment. All emergency medical services were notified as to the timing of the treatment.

While the major steps carried out during the implementation phase are presented below, many steps were actually taken but are too detailed to list here.

Monitoring and environmental effects mitigation

Benthic (Ontario Benthic Monitoring Protocol) and fish community monitoring was carried out pre-treatment and the assessment information recorded for comparison with the post-treatment recovery (Marson and Mandrak 2009).

A week before treatment, to ensure that flow and duration of treatment calculations were correct, a test was conducted by DFO using the dye used to track the piscicide during treatment. Water samples were collected at intervals and the dye detected through

spectophotometry (Borwick 2005). Laboratory bioassays were conducted with live goby to ensure effective concentrations were used during treatment.

A week before treatment (October 11-14, 2005), in a massive co-operative undertaking, as many fishes as possible were removed from the experimental area and released into Lake Simcoe. The fish were captured live, using electrofishing equipment, sorted, measured and counted. Species captured included minnows, Emerald Shiner (*Notropis atherinoides*), Pumpkinseed (*Lepomis gibbosus*), Yellow Perch (*Perca flavescens*), Largemouth Bass (*Micropterus salmoides*), Smallmouth Bass (*Micropterus dolomieu*), Bluegill (*Lepomis macrochirus*), and Northern Pike (*Esox lucius*). Approximately 10,000 fish, including over 4,000 sport fish, were transferred into Lake Simcoe (OMNR 2006). Five hundred and forty-nine Round Goby were captured and retained for bioassay studies carried out to determine the effective concentration of rotenone.

Public concerns mitigation

Consultation continued with the stakeholders during the summer of 2005 with an Invasive Species Workshop held in Georgina. Announcements through the radio public service and a media release by OMNR kept the public apprised of the ongoing monitoring efforts throughout the summer. Signage was placed throughout the treatment area forty-eight hours prior to treatment. Bottled water was provided to those residents drawing surface water. An on-site information centre was set-up and operated during the fish removal process and throughout the treatment phase. Conservation Officers were on hand to answer questions and alternative launching sites for boats were provided where required. If it was necessary for members of the general public to travel through the treatment site during treatment, an escort was provided (Borwick 2005).

1.2.6.2. Treatment

A 5 km portion of Pefferlaw Brook, downstream of the dam was treated over a three-day period (October 18-20, 2005). Licensed applicators from the DFO Sea Lamprey Program conducted the treatment. Cages containing Round Goby and other fish species were immersed in the treatment area to ensure the correct toxic concentration was reached. The treatment area included side channels, tributaries, and the waters in, and around, the breakwall near the mouth of the brook. A dye was released with the chemical mixture and water samples taken every hour to track the chemical as it flowed downstream (Borwick 2005).

Details of Treatment

The piscicide used in the treatment of Pefferlaw Brook was ChemFish Regular 5% (active ingredient rotenone). Two types of application were required: a 'stream type' application which uses the stream current to transport the rotenone (estimated concentration of 2 ppm); and, a 'lake' application used for the downstream section, including the backwaters, marinas, and boating channels where the stream is wider and slower moving (estimated concentration of 4 ppm). For the 'lake' application, the chemical was added into the water from boats fitted with drip lines directing the product into the propeller wash. Boats zig-zagged back and forth in pre-defined quadrants to effectively disperse chemical throughout quadrants. A drip station was set up at the Pefferlaw Dam to apply the chemical at the 2 ppm concentration. The outside of the breakwall, areas not accessible by boat, and areas with no flow were treated using backpack sprayers (DFO-MOE 2005).

1.2.6.3. Post Treatment

Fish Removal and Disposal

The removal and disposal of the dead fishes took place October 18-25, 2005. A crew of agency and staff and volunteers was coordinated to collect the dead fishes after the treatment. A private waste company was hired to dispose of the fishes in a landfill site. A total of 4.85 metric tonnes of dead fishes were collected from the treated area: approximately 95% consisted of shiner species and Common Carp (*Cyprinus carpio*), other species included Yellow Perch, White Sucker (*Catostomus commersonii*), Rock Bass (*Ambloplites rupestris*), Sunfishes (*Lepomis* spp.), Smallmouth Bass, Black Crappie (*Pomoxis nigromaculatus*), and Bullheads (*Ameiurus* spp.) (DFO-MOE 2005). Although many Emerald Shiner were killed during treatment, the main fall run had not yet started (Borwick 2005). Round Goby were not found in any areas not previously known to contain Goby (OMNR 2006).

1.2.7. FOLLOW-UP PHASE (fall 2005- summer 2006)

As required by the OMOE *Pesticides Act* and the *CEAA*, follow-up fish, benthic invertebrate and water quality monitoring was undertaken. Preliminary analyses indicated no significant difference in benthic organisms. Native fish and benthic organisms were present in the brook two weeks post-treatment. Monitoring continued until ice-up and no Round Goby were detected (Borwick 2005; Marson and Mandrak 2009). There was no migration of rotenone into the groundwater, and the rotenone was almost completely detoxified one day after application. There was no significant increase in volatile organic compounds (VOCs) (DFO-MOE 2005; Borwick 2005).

Monitoring continued immediately after ice-out in spring 2006. Initially, no Round Goby were detected, and native fishes were found to be re-colonizing the treated area of Pefferlaw Brook (Marson and Mandrak 2009). Appendix 2 provides a list of species detected in Pefferlaw Brook pre- and post-treatment. There were also anecdotal reports of additional species returning, notably an abundant spring Walleye (Sander vitreus) spawning run (OMNR 2006).

During a routine check in May 2006, one Round Goby was found in the Morning Glory Road area, the site of the first detection in 2004. Monitoring was intensified through use of seine nets and three more Round Goby were found.

The Technical Committee (DFO, OFAH, University of Windsor, OMNR) was consulted to determine if any measures could be undertaken to prevent re-invasion with the resulting spread to Lake Simcoe. It was agreed, as the numbers of Goby detected were low, that the speedy removal of as many Goby as possible would be the best course of action (OMNR 2006).

Throughout the summer of 2006, monitoring and removal of Round Goby continued. An additional rotenone treatment was not possible as the original treatment was permitted as a single application experimental treatment. Additional traps were set and techniques, such as seining, electrofishing, and angling, were used to remove as many Goby as possible. Volunteers and staff were enlisted to help with the effort. A public meeting was held June 28, 2006, hosted by OMNR, to update the public on the eradication project and provide the results from the treatment phase.

Small numbers of Round Goby were captured throughout the summer of 2006, totalling approximately 40 fish. Evidence of reproduction was found. In late July, OMNR and the Lake Simcoe Fisheries Assessment Unit trawled the mouth of Pefferlaw Brook in Lake Simcoe and

captured one Round Goby. With this discovery, OMNR and its partners agreed that it was no longer possible to eradicate Round Goby from the Lake Simcoe watershed (OMNR 2006).

Monitoring and removal of Round Goby continued for the remainder of the 2006 season, with the traps being moved to the nearshore areas of Lake Simcoe. With the discovery of Round Goby in Lake Simcoe, efforts shifted to monitoring their spread within Lake Simcoe (LSEMS 2008).

1.3.0. DISCUSSION

Although the rapid response to the presence of Round Goby in Pefferlaw Brook was not successful in eradicating Round Goby from the brook, or preventing its spread into Lake Simcoe, partial mitigation was achieved as the rate of spread was greatly reduced.

DFO sampling of the pre- and post-treatment fish assemblages of Pefferlaw Brook indicated a successful recovery of fishes. Through standardized sampling by DFO, 40 species were captured prior to the application of rotenone, compared to 37 species detected following treatment (Appendix 2). Sport fish catch numbers post-treatment were close to pre-treatment numbers (Marson and Mandrak 2009).

This was the first time in North America that eradication of Round Goby was attempted (Borwick 2005). Valuable experience was gained that will enhance rapid response planning and implementation as well as the management of Round Goby in other waters.

Communication, monitoring, and data acquisition and review were actions that were repeated in each phase of the rapid response, an indication of the importance of these tasks to a rapid response effort. A summary of communication tasks undertaken in each phase is provided in Appendix 4.

The rapid response to Round Goby in Pefferlaw Brook demonstrated the willingness of groups and agencies to work together. Numerous governmental agencies and community groups came together, frequently providing expertise and time in lieu of hard costs.

There has been some speculation as to whether earlier detection of Round Goby in Pefferlaw Brook would have led to a more successful outcome. Round Goby were suspected to reside in Pefferlaw Brook for some time, possibly years, before the report submitted in August of 2004 initiated the rapid response (DFO 2005). Early and accurate recognition of the problem is known to be key to a successful eradication program (McEnnulty *et al.* 2000). Control options were also limited when Round Goby were discovered in the brook during the spring following treatment. A follow-up rotenone treatment was not possible as the original treatment was permitted as a single application experimental treatment.

In an effort to slow the spread of Round Goby, it has been illegal in Ontario to possess Round Goby alive since the fall of 2005. Goby are not listed as legal baitfish species in the Ontario Fishery Regulations so cannot be used as bait In addition, OMNR, in cooperation with the commercial bait industry, has implemented mandatory completion of MNR approved Hazard Analysis and Critical Control Point (HACCP) plans for bait harvesters (implemented January 2007) and bait dealers (effective January 2008) that includes training to identify critical points for preventing the spread of aquatic invasive species, thus reducing accidental transfers.

PART 2. AN EVALUATION OF THE RAPID RESPONSE FRAMEWORK BASED ON THE PEFFERLAW BROOK EXPERIENCE

2.1.0. INTRODUCTION

A formal procedure for rapid response is not yet in place in Canada (Vernon *et al.* 2008). Wotten and Hewitt (2004) identified as one of the main components of an effective rapid response system the development of processes and plans to guide the response actions. To address this, and to begin the development of a national protocol, Locke and Hanson (2009b) developed a framework that can be used to develop rapid response plans against invasions of unwanted aquatic non-indigenous species in Canada. The proposed framework was primarily developed using principles gained from review of case studies of rapid response efforts both internationally (Locke and Hanson 2009a) and in Prince Edward Island (Locke *et al.* 2009).

In the absence of formal rapid response plans, the *ad hoc* rapid response to Round Goby in Pefferlaw Brook incorporated many elements of the proposed framework. In fact, as demonstrated in the first section of this report, it was possible to organize the steps taken in the Pefferlaw rapid response according to the steps outlined in the proposed framework. This section will evaluate the rapid response framework, for completeness, and where possible efficiency and effectiveness, based on the Pefferlaw experience.

The framework consists of a series of pre- and post-invasion actions. As few of the pre-invasion steps were in place, the emphasis will be on the post-invasion actions. Pre-invasion processes are discussed, where possible, with reference to outcomes of the Pefferlaw Brook experience. The framework has been provided in its entirety, as a checklist, in Appendix 3.

2.2.0. EVALUATION OF THE PHASES OF THE PROPOSED FRAMEWORK

The framework identifies steps for general preparation before an invasion and six phases in the pre and post-invasion processes:

- General Preparation
- Detection Phase
- Demarkation Phase
- Containment Phase
- Risk Assessment Phase
- Implementation Phase
- Follow-up Phase

Each phase will be discussed in the context of Pefferlaw Brook in the following sections. The steps outlined in the framework are provided as bulleted points for each phase.

2.2.1. GENERAL PREPARATION BEFORE AN INVASION

- Understand all relevant laws, regulations, policies and guidelines that may affect the ability to undertake a rapid response.
- Identify who is responsible overall, and for each step in the rapid response.

- Identify a primary point of contact at each local, provincial, and federal agency involved, and at major stakeholder organizations as appropriate.
- Identify the source of funding.
- Identify existing frameworks, networks, etc., that may be useful in developing or implementing a rapid response plan.
- Develop a communication structure.

OMNR was the lead agency in this endeavour and was prepared to front the costs of the project, which allowed the project to proceed quickly and smoothly. While not formally in place for rapid response, well-established, multi-agency, working relationships were already in existence prior to the Pefferlaw project, for example, the OMNR/OFAH partnership for the Invading Species Awareness Program.

2.2.2. DETECTION PHASE

Pre-invasion

- Species of concern: develop criteria for listing species of concern; develop a list of species of concern, make provision for dealing with species of concern.
- Make provision for dealing with species not on the list.
- Develop monitoring networks:
  - develop monitoring network coordination;
  - develop a monitoring protocol.
- If necessary, conduct ecological inventories to establish baseline information on native and aquatic invasive species (AIS) populations.
- Develop protocol for identification of invaders.
- Develop a database of regional AIS sightings and established AIS populations.
- Communications:
  - list the stakeholders and agencies that should be notified in the event of detection;
  - develop educational materials;
  - develop a dedicated website and toll-free telephone number to report sightings or access information on invasions; and,
  - prepare generic press release statements.

Post-invasion

- Report the suspected AIS to the authority who then completes the following steps:
- Confirm identity.
- Deposit voucher specimen at the appropriate permanent archive.
- Update the database and web pages (see pre-invasion steps above).
- Mobilize the communication officer and scientific advisory team.

The Pefferlaw project demonstrated the importance of most of the pre-invasion steps outlined in the framework. Early and accurate recognition of the problem increases the chance of a successful rapid response (McEnnulty *et al.* 2000). Pre-existing and accessible data on known species of concern facilitate a rapid response. In the case of Pefferlaw Brook, Round Goby was already established as a species of concern, having colonized all of the Great Lakes since first being reported approximately 10 years before the Pefferlaw Brook infestation. The known threat of the Round Goby and the readily accessible data permitted an immediate decision on the management goal - the prevention of Round Goby from entering Lake Simcoe.

Information on Round Goby as a pest was readily available to the public on the website www.invadingspecies.com, a website developed as part of a joint initiative between OMNR and OFAH - the Invading Species Awareness Program. This website allows the public to report AIS sightings and provides information on regional invasive species, including the Round Goby, information that most likely contributed to the public awareness of this species. The 'Invading Species Hotline', a toll free number to report invasive species, is also provided through this initiative. The first Round Goby discovered in Pefferlaw Brook was reported by the angler to this hotline. It is clear from the Pefferlaw experience that having information readily available to the public and stakeholders regarding potential AIS, and having a mechanism to report suspected AIS, prior to discovery of an invasion, can play an important role in early detection. Although a formal process for identification was not in place, identification was confirmed immediately by biologists at the Lake Simcoe Fisheries Assessment Unit and verified within days at the Royal Ontario Museum in Toronto.

In measuring the success of the Round Goby eradication project, it becomes clear that the establishment of a formal monitoring network and monitoring protocol for a timely discovery of an invasion is key to the outcome of a rapid response. The primary goal of the Pefferlaw Brook eradication project was to prevent Round Goby from entering Lake Simcoe, and in this endeavour, it failed. Although by no means certain that an earlier detection would have altered the outcome of the Pefferlaw Brook project, early detection is key for the success of a rapid response as populations that are in their early stages and locally distributed are more likely to be successfully contained or eradicated than are established populations (NISC 2003). The discovery of the first Round Goby in Pefferlaw Brook, the event that initiated the whole process, was a fish caught by an angler. There was no formal monitoring in place. It is suspected that Round Goby had been present in Pefferlaw Brook for quite some time, possibly years before it was noticed, as local residents reported catching them at the initial site of detection for up to 2 years prior to the report in 2004 (DFO 2005).

Baseline data were available for the native species of Pefferlaw Brook. These data streamlined the response as it was already established that no species at risk were present in the study area, simplifying the approval process.

Although a communication officer and a scientific advisory team were not in place, an intensive public awareness campaign was immediately undertaken by OMNR and OFAH, as it was clear that, in the case of Round Goby in Pefferlaw Brook, prompt action had to be taken to prevent the infestation of Lake Simcoe. Identifying an objective and initiating a public awareness campaign at this early stage of the response can enlist public support and assistance in determining the distribution of the AIS, may also stop further infestation, both in the area of concern and other areas as public awareness is heightened, and may garner public support for action. It is recommended, based on the Pefferlaw experience, that the framework provides a clear step at this point (post-invasion detection phase) for identifying and declaring a management objective (in this case to prevent Round Goby from entering Lake Simcoe from Pefferlaw Brook) when the circumstances warrant it and existing data on the AIS support it. The subsequent phases outlined in the framework must still be worked through to determine if the objective is attainable, and if so, how best to attain it.

Summary Evaluation of Detection Phase of Framework

- Pre-invasion steps are complete and relevant - of particular importance is:
  - having readily accessible data for known species of concern and making these data available to the public; and,
  - developing monitoring networks.

- Post-invasion steps are relevant - of particular importance is:
  - providing an efficient method of identification of a suspected AIS;
  - providing a mechanism through which a suspected AIS can be reported; and,
  - initiating a public awareness campaign as soon as possible.

Recommendations for Detection Phase of Framework

- Post-invasion phase - add a step for identifying and declaring a management objective when circumstances warrant immediate action and existing data support the objective.

2.2.3. DEMARKATION PHASE

Pre-Invasion

- Identify who will conduct biological surveys for various environments/species, and collect data for risk assessment.
- Determine the likely composition of potential scientific assessment committees for various kinds of AIS.
- Communications: Develop a strategy for stakeholder consultation and communication of information.

Post-Invasion

- Determine distribution of invader and other relevant data needed for risk assessment, including vectors and options for containment.
- Convene scientific assessment committee and review preliminary data.
- Continue communicating with stakeholders as new information becomes available.
- Begin stakeholder consultation to determine the need (or legal requirement) for management.

The proposed framework recommends pre-invasion decisions on responsibility for data collection. As mentioned above, working relationships were already in existence prior to the Pefferlaw project. For example, the OMNR/OFAH partnership for the Invading Species Awareness Program was in place as was an ongoing provincial research initiative, involving numerous research institutions and partners, to study Round Goby behaviour and develop management and control tools to prevent their spread. (The Pefferlaw Brook project was undertaken as part of this initiative.) These partnerships and the ongoing research initiative mirror, to some extent, the data requirements and scientific input outlined in the demarkation phase of the pre-invasion process framework, improving the efficiency of the rapid response. All the post-invasion steps outlined in the framework were undertaken in the Pefferlaw Brook project. Determining the distribution of the invader, not only in Pefferlaw Brook, but in Lake Simcoe and other tributaries, was critical for deciding whether to proceed with the rapid response. The vector was thought to be contamination through the transfer of live bait, an illegal practice that could be targeted through the public awareness program.

The residents in the Lake Simcoe watershed, as a result of the initial intensive public awareness campaign, already had a heightened awareness of the harmful effects of invasive species, including Round Goby, and there was an expectation for action within the local community (OMNR 2005d). Ongoing communication efforts, including the Invasive Species Workshop, kept the public informed and provided a forum for input as well as volunteerism. Public and stakeholder support for action facilitates the response process.

Summary Evaluation of Demarkation Phase of Framework

- Pre-invasion steps, as outlined in the framework, were not in place for the Pefferlaw Brook rapid response but pre-existing partnerships in the Pefferlaw exercise demonstrated the importance of establishing relationships prior to an infestation.
- Post-invasion steps are relevant and complete - of particular importance is:
  - determining the distribution of the AIS; and,
  - communication with stakeholders and public.

Recommendations

- Post-invasion phase - include 'the public' in the post-invasion steps for communicating with stakeholders and stakeholder consultation (e.g., 'continue communication with stakeholders and the public').

2.2.4. CONTAINMENT PHASE

Pre-Invasion

- Develop criteria for determining the need for containment or restriction of use of an infested waterbody.
- Determine whether legal authorities will allow containment or restriction of use of the waterbody.
- Identify who is responsible for the enforcement of restrictions of specific systems, what enforcement resources may be required, and how to obtain additional resources or funding, if needed.
- Communications strategy for the containment phase: identify the communication needs associated with containment or restriction of use.

Post-invasion

- Scientific advisory committee evaluates need for containment or restriction and continues to assess risk.
- Communicate the decision. Commence containment or restriction of use of the infested water body or facility, if necessary.
- Continue stakeholder consultation.
- Monitor the infestation.

In the case of Pefferlaw Brook, the potential need for containment to prevent Round Goby from entering Lake Simcoe was already recognized. When ongoing monitoring confirmed the movement of Round Goby downstream and at the mouth of the brook in the summer of 2005, silt curtains were erected at the breakwalls as a temporary containment measure.

Communication with stakeholders continued with information packages sent to baitfish retailers and harvesters. The Goby Fishing Derby was held to assist with monitoring and to raise public awareness and foster support from the public for the eradication of Round Goby from the brook.

In the case of Round Goby, although a formal risk assessment was not conducted, there was already an established awareness of risks and potential impacts. What was at risk was also well known (the Lake Simcoe fishery and aquatic ecosystem). Monitoring the infestation proved critical as the decision for containment was necessitated by the movement downstream of Round Goby, increasing the risk of infection of Lake Simcoe.

Summary Evaluation of Containment Phase of Framework

- Pre-invasion steps, as outlined in the framework, were not in place for the Pefferlaw Brook rapid response, but existing data on Round Goby and knowledge of the fishery in Lake Simcoe facilitated the decision for containment as would a pre-invasion risk assessment for high priority species.
- Post-invasion containment steps adequately describe what actually occurred in Pefferlaw Brook - of particular importance is:
  - monitoring the infestation.

2.2.5. RISK ASSESSMENT PHASE

Pre-Invasion

- Identify who will conduct the risk assessment.
- Identify the information needs for risk assessment, develop the required protocols, ensure appropriate equipment and personnel will be available, and provide training to personnel.
- Identify control options for 'invasive species of concern'.
- Formalize the decision support system for risk assessment and provide training.

Post-Invasion

- Continue to assemble data on the affected area.
- Review the control options: identify risks and benefits associated with various controls, including no control.
- Select the preferred control option and document rationale.
- Set schedule for implementation.
- Communicate the decision.

The development, pre-invasion, of control options for 'invasive species of concern' would facilitate the response. In the case of Pefferlaw Brook, a consulting firm was hired to determine management options for the removal of Round Goby. The information gathered from this exercise will add to the knowledge base for future responses to Round Goby.
Locke and Hanson (2009b) provide an assessment matrix with the proposed framework, to assist with the comparison and selection of control options in the pre-invasion phase. Within this matrix, additional considerations are presented, such as cost of treatment and determining what approvals and permits are required for each option. Estimation and consideration of cost and approvals should be added up front to the pre-invasion steps of the risk assessment phase, however, as they are key to being prepared and able to proceed in a timely way. In the case of Pefferlaw Brook, the registration of rotenone as a piscicide had expired. Keeping registrations current would facilitate the rapid response.

As funding issues and permit and approval requirements are key to proceeding with the action, and cannot be predicted precisely except on a case by case basis, consideration of these steps should be included in the post-invasion steps as well. In the case of Pefferlaw Brook, budget plans included requesting funding and in-kind support from partner agencies and organizations to help offset the overall cost of the eradication project, but OMNR was prepared to initially front end the project cost.

Probable quarantine needs during implementation, mitigation efforts, and post-treatment clean-up steps could be pre-planned to some extent and included with specific management options in the risk assessment pre-invasion phase.

Characterization of the site, including physical structure of the site, flow data, bathymetric data, water temperature, etc., is an important component of the decision-making process in the selection of a control option and in scheduling implementation. Although alluded to, perhaps this step should be emphasized in the framework.

'Communicate the decision' is a very important component of the risk assessment phase. In the case of Pefferlaw Brook, the decision to apply a piscicide was a potentially contentious issue; consequently, a great deal of preparation went into the communication of the decision to the public. Pre-public meetings were held with local politicians, with the hope of gaining their endorsement of the plan. Fact sheets and information bulletins were prepared to address the public's concerns about the use of a pesticide. There was already a will to act on the part of the public, and a well executed presentation of the plan to the public avoided time costly delays to the implementation of the treatment.

Summary Evaluation of Risk Assessment Phase of Framework

- Pre-invasion steps, as outlined in the framework, were not in place for the Pefferlaw Brook rapid response but the rapid response exercise demonstrated the importance of developing control options for high priority species, including permits and approvals required for each option.
- Post-invasion steps are relevant - of particular importance is:
  - communication of the selected control option to the public.

Recommendations

- Put the risk assessment and control option components in separate phases.
- Pre-invasion phase - include estimation of cost and approvals required, including expected timelines to receive approvals, for each control option, as well as probable quarantine needs, mitigation efforts, and post-treatment clean-up.
- Post-invasion phase - re-visit funding and permits and approvals required in the context of the selected control option; compile and collect data for characterization of the affected area.

2.2.6. IMPLEMENTATION PHASE

Pre-Invasion

- Identify who is responsible for implementation of the rapid response.
- Develop protocols for the control methods that may be used.
- Provide training to rapid response group members with simulations and field trials.
- Develop communications strategy for the implementation phase.

Post Invasion

- Begin experimental or full-scale management effort.

Although the pre-invasion steps were not formally in place at the time of the Pefferlaw eradication project, protocols for the control option selected for Pefferlaw Brook were already developed, as the application of rotenone is a proven method having been used extensively in North America for fisheries management and by OMNR in Ontario. Trained, licensed applicators from the DFO Lamprey Program applied the piscicide.

Several critical steps were taken in the Pefferlaw exercise that should be highlighted and included in the post-invasion implementation phase of the framework. These include: deciding if the treatment area needs to be quarantined from the public; monitoring of the benthic and fish populations pre-treatment; mitigation of both environmental effects and public concerns; and implementation of post-treatment clean-up tasks, if required. Although clearly applicable to a response requiring application of a chemical that causes a great deal of collateral damage, these steps would apply to most rapid response implementations. As mentioned above, probable quarantine needs during implementation, mitigation efforts, and post-treatment clean-up steps could be pre-planned to some extent and included with specific management options in the risk assessment pre-invasion phase.

At the Pefferlaw study site, restricting water access to the public during treatment was necessary. Forty-eight hours prior to the treatment signs were posted throughout the treatment area, and alternative sites were provided for boat launching. Escorts were provided if travel on the study site was required during treatment.

To ensure that flow and duration of treatment calculations were accurate, a dye test was carried out by DFO Sea Lamprey Control staff a week prior to the actual treatment on Pefferlaw Brook. This allowed the rapid response to use less rotenone than recommended by the consultant. Also, to minimize the collateral damage, as many fishes as possible were transferred from the study site prior to treatment in a massive fish rescue operation. Data collected from this operation were collected for post-treatment comparisons.

An on-site information centre was set-up and operated throughout the fish removal operation and the treatment phase with experts on hand to answer questions and address concerns. Bottled water was provided for those residents drawing surface water and all emergency health services were notified of the plan and schedule.
Fish removal and disposal post-treatment was a necessary requirement of the rapid response in Pefferlaw Brook that needed to be carried out quickly. The implementation phase would not have been able to proceed without plans in place for this very important step. The fish removal process started during treatment and continued past the conclusion of the exercise.

Summary Evaluation of Implementation Phase of Framework

- Pre-invasion steps, as outlined in the framework, were not in place for the Pefferlaw Brook rapid response but their relevance was confirmed - for example, existing protocols for the selected control option demonstrated the importance of developing protocols for various control options prior to infestation.
- Post-invasion steps require more detail (see Recommendations below).

Recommendations

- Post-invasion phase - add the following steps: determine if quarantine of treatment area is required during implementation of the control option; monitor the benthic and fish populations pre-treatment; mitigation of environmental effects and public concerns; implementation of post-treatment clean-up, if required.

2.2.7. FOLLOW-UP PHASE

Pre-Invasion

- Identify who is responsible for post-treatment monitoring.
- Identify protocols to be used in pre- and post-treatment monitoring to assess the effectiveness of the selected response.

- Identify protocols to evaluate the effectiveness of communication.

Post-Invasion

- Monitor for long enough to ensure the response was effective.
- Determine if response is complete.
- Take measures to prevent reinvasion.
- Communicate the results.
- Evaluate the effectiveness of communication.
- Debrief the process.

Monitoring of Pefferlaw Brook continued during the summer of 2006. Although Round Goby was detected in the brook, numbers were very low and removal was still considered an option in the continued attempt to prevent the invasion of Lake Simcoe. An evaluation of the effectiveness of the rapid response would be a useful step to add to the post-invasion part of the follow-up phase of the framework. This step could include recommendations on further actions required, if any. It would be useful to consider the effectiveness of the response and the completion of the response separately to accommodate the various outcomes of a rapid response.

A public meeting was held during this phase, to update the public on the status of ongoing monitoring as well as the results of the treatment phase. It is recommended that 'communicate to the public results of the rapid response' be added to the framework in the post-invasion part of the follow-up phase.

Eventually, in the summer of 2006, a Round Goby was captured in Lake Simcoe, at the mouth of Pefferlaw Brook, and the response was considered complete as the goal of preventing the invasion of Lake Simcoe was no longer attainable.

Summary Evaluation of Follow-up Phase of Framework

- Pre-invasion steps, as outlined in the framework, were not in place for the Pefferlaw Brook rapid response.
- Post-invasion steps are relevant.

Recommendations

- Post-invasion phase - add the following steps: evaluate the effectiveness of the rapid response and recommend further action, if required; assess "lessons learned" to improve rapid response framework and future rapid responses; and, communicate the results of the rapid response to all stakeholders and the public.

2.3.0. CONCLUSION

The comfortable 'fit' of the Pefferlaw rapid response into the proposed framework, as shown in Part 1 of this report, demonstrates that the framework provides a logical and practical approach for a rapid response. Although the framework was shown to be very complete, evaluating the framework in the context of the Pefferlaw Brook exercise made it possible to identify several modifications that may be helpful. These are summarized and provided in the Recommendations section below.

The proposed framework, especially if used as a checklist, suggests a linear approach, a step by step implementation of the rapid response. The Pefferlaw Brook experience indicates that in

reality, this is not necessarily the way the response progresses. Although it does not appear that any steps could be skipped, some of the steps in the phases overlapped. For example, once monitoring of the infestation has been initiated in the containment phase, it is continued throughout the rapid response, until the rapid response is deemed complete, in the follow-up phase. It is important to note that implicit in the monitoring process is the ability to stop the rapid response if, at any time, it becomes clear that the objective is no longer feasible - in the case of Pefferlaw Brook the detection of Round Goby in Lake Simcoe. The requirement for containment also could arise anytime during the pre-treatment phases, depending on the results from monitoring. In the case of Pefferlaw Brook, the movement of Round Goby necessitated the erection of silt curtains as a temporary containment measure in September, during what could be classified as the Risk Assessment Phase.

2.4.0. SUMMARY OF RECOMMENDATIONS

Based on the evaluation of the proposed national framework for rapid response in the context of Pefferlaw Brook, the following modifications to the framework are recommended:

All phases

Post-invasion

- Include a step for a decision to terminate the rapid response if it becomes clear that the objective is no longer feasible.

Detection Phase

Post-invasion

- Set objective - include a step for identifying and declaring a management objective at this early stage when the circumstances warrant it and existing data on the AIS supports it.

Demarkation Phase

Post-invasion

- Include 'the public' in the post-invasion steps for communicating with stakeholders and stakeholder consultation.

Risk Assessment Phase

Pre-invasion

- Put the risk assessment and control option components in separate phases.
- Estimate funding requirements and approvals specific to each management option under consideration.
- Decide who is responsible for paying for the implementation of the selected response.
- Identify probable quarantine needs, mitigation efforts, and post-treatment clean-up steps specific to each management option under consideration.

Post-invasion

- Determine funding needs.
- Determine required permits and approvals.
- Finalize who is responsible for paying for the implementation of the selected response.
- Compile and collect data for characterization of the affected area.

Implementation Phase

Post-invasion

- Decide if the treatment area needs to be quarantined from the public.
- Monitor benthic and fish populations pre-treatment.
- Mitigate environmental effects and public concerns (communication).
- Implement post-treatment clean-up tasks, if required.

Follow-up Phase

Post-invasion

- Evaluate the effectiveness of the rapid response, include recommendations on further actions required, if any.
- Assess "lessons learned" to improve rapid response framework and future rapid responses.
- Communicate to all stakeholder and the public the results of the rapid response.

REFERENCES

Borwick, J. 2005. Ontario's response to detecting Round Goby: an eradication case study. OMNR Aurora. http://www.icais.org/pdf/2006ppt/Borwick_Jason.pdf [presentation]. Accessed February 8 2009.

Corkum, L.D. 2004. Pheromone signalling in conservation. Aquatic Conservation: Marine and Freshwater. Ecosystems. 14: 327–331.

Corkum, L.D., Spaota, M.R., and Skora, K.E. 2004. The round goby, *Neogobius melanostomus*, a fish invader on both sides of the Atlantic Ocean. Biological Invasion 6: 173-181.

Cudmore, B. and Koops, M.A. 2007. Risk assessment of round goby (*Neogobius melanostomus*) to Lake Simcoe, Ontario: a quantitative biological risk assessment tool (QBRAT) study. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/038.

Fisheries and Oceans Canada (DFO). 2005. DFO sampling methodology. Unpublished Report. 4 p.

Fisheries and Oceans Canada (DFO). 2008. A Canadian action plan to address the threat of aquatic invasive species. http://www.dfo-mpo.gc.ca/science/enviro/ais-eae/plan/plan-eng.htm Accessed March 26 2009.

Fisheries and Oceans Canada and Ontario Ministry of the Environment (DFO-MOE). 2005. DFO permit requirements- DFO MOE final report. Unpublished Report. DFO Peterborough District Office. 3 p.

Greenland International Consulting Ltd. 2005. Site condition report for assessing round goby removal and eradication options for Pefferlaw Brook. Draft. 57 p.

Lake Simcoe Environmental Management Strategy (LSEMS). 2003. State of Lake Simcoe Watershed Report 2003. 215 p. http://www.lsrca.on.ca/PDFs/statehr.pdf Accessed March 12 2009.

Lake Simcoe Environmental Management Strategy (LSEMS). 2008. Lake Simcoe Basin Wide Report. March 20, 2008. 135 p. https://ospace.scholarsportal.info/bitstream/1873/10343/1/280971.pdf . Accessed March 18 2009.

Locke, A. and Hanson, J.M. 2009a. Rapid response to non-indigenous species. 1. The goals and history of rapid response in the marine environment. Aquatic Invasions 4: 237-247.

Locke, A. and Hanson, J.M. 2009b. Rapid response to non-indigenous species. 3. A proposed framework. Aquatic Invasions 4: 259-273.

Locke, A., Hanson, J.M., MacNair, N.G., and Smith, A.H. 2009. Rapid response to non-indigenous species 2. Case studies of non-indigenous tunicates in Prince Edward Island. Aquatic Invasions 4: 249-258.

Marson, D. and Mandrak, N.E. 2009. Changes in fish assemblages in Pefferlaw Brook following rotenone treatment, 2005-2006. Can. MS. Fish. Aquat. Sci. iv + 21 p.

McEnnulty, F.R., Bax, N.J, Schaffelke, B., and Campbell, M.L. 2000. A review of rapid response options for the control of ABWMAC listed introduced marine pest species and related taxa in Australian waters. Centre for Research on Introduced Marine Pests Tech Rep 23. CSIRO Marine Research, Hobart Australia.

National Invasive Species Council (NISC). 2003. General guidelines for the establishment and evaluation of invasive species early detection and rapid response systems. Version 1. 16 p.

Ontario Federation of Anglers and Hunters (OFAH). 2009. Invading Species Awareness Program. http://invadingspecies.com/Invaders.cfm?A=Page&PID=8 Accessed February 8 2009.

Ontario Ministry of Natural Resources.2005a. Protecting what sustains us - Ontario Biodiversity Strategy . 53 p. http://www.mnr.gov.on.ca/MNR_E000066.pdf Accessed March 18 2009.

Ontario Ministry of Natural Resources (OMNR) 2005b. Proposal to remove Round Goby from the Pefferlaw Brook. Draft report. 16 p.

Ontario Ministry of Natural Resources (OMNR) 2005c. Round Goby- aquatic invasive species- options for removal from the Pefferlaw Brook. Draft Technical Communication 9 p.

Ontario Ministry of Natural Resources (OMNR) 2005d. Pefferlaw goby removal issue management strategy. Draft report 9 p.

Ontario Ministry of Natural Resources (OMNR). 2006. Resource Report: Fishing Lake Simcoe Newsletter. 2006 Annual Issue. 8 p. http://www.lakesimcoemessageboard.com/lake_simcoe_report.pdf Accessed March 18 2009.

Vernon, G.T., Vásárhelyi, C., and Niimi, A. 2008. Legislation and the capacity for rapid-response management of nonindigenous species of fish in contiguous waters of Canada and the USA. Aquatic Conservation: Marine and Freshwater Ecosystems. 19(3):354-364.

Western Aquatic Nuisance Species Panel (WANS). 2003. Model rapid response plan for aquatic nuisance species. Prepared for the Western Regional Panel on Aquatic Nuisance Species by California Department of Food and Agriculture. 60 p. http://www.fws.gov/answest/Docs/WRP%20RRP%20Final,%20Part%20II.pdf Accessed March 18 2009.

Wotten, D.M. and Hewitt, C.L. 2004. Marine biosecurity post-border management: developing incursion response systems for New Zealand. New Zealand Journal of Marine and Freshwater Research 38:553-559.

APPENDIX 1: SUBWATERSHEDS OF LAKE SIMCOE

(Greenland International 2005)

(source Lake Simcoe Region Conservation Authority)

REFERENCES

Greenland International Consulting Ltd. 2005. Site condition report for assessing round goby removal and eradication options for Pefferlaw Brook. Draft Report. 57 p.

APPENDIX 2: FISH SPECIES CAPTURED IN PEFFERLAW BROOK PRE- AND POST-TREATMENT

Common Name	Scientific Name	Pre-Treatment[1]	Post- Treatment[1]
Banded Killifish	*Fundulus diaphanus*	✓	+
Black Bullhead	*Ameiurus melas*	+✓	
Black Crappie	*Pomoxis nigromaculatus*	+	
Blackchin Shiner	*Notropis heterodon*		+
Blacknose Dace	*Rhinichthys atratulus*	x✓	
Blackside Darter	*Percina maculata*	+✓	+
Bluegill	*Lepomis macrochirus*	+✓	+
Bluntnose Minnow	*Pimephales notatus*	+x✓	+
Bowfin	*Amia calva*	+	+
Brassy Minnow	*Hybognathus hankinsoni*	✓	
Brook Silverside	*Labidesthes sicculus*		+
Brook Stickleback	*Culaea inconstans*	+	+
Brown Bullhead	*Ameiurus nebulosus*	+x✓	+
Brown Trout	*Salmo trutta*	✓	
Central Mudminnow	*Umbra limi*	+✓	+
Central Stoneroller	*Campostoma anomalum*	✓	+
Cisco (Lake Herring)	*Coregonus artedii*	x	
Common Carp	*Cyprinus carpio*	+✓	+
Common Shiner	*Luxilus cornutus*	+x✓	+
Creek Chub	*Semotilus atromaculatus*	+x✓	+
Emerald Shiner	*Notropis atherinoides*	+✓	+
Emerald Smelt	*Osmerus mordax*	+	+
Fathead Minnow	*Pimephales promelas*	+x✓	+
Finescale Dace	*chrosomus neogaeus*	+	
Ghost Shiner	*Notropis buchanani*		+
Golden Shiner	*Notemigonus crysoleucas*	+x✓	+
Green Sunfish	*Lepomis cyanellus*	✓	
Greenside Darter	*Etheostoma blennioides*	✓	
Hornyhead Chub	*Nocomis biguttatus*	+x✓	+
Iowa Darter	*Etheostoma exile*	+✓	+
Johnny Darter	*Etheostoma nigrum*	+x✓	

APPENDIX 2: FISH SPECIES CAPTURED IN PEFFERLAW BROOK PRE- AND POST-TREATMENT (CONT'D)

Common Name	Scientific Name	Pre-Treatment[1]	Post- Treatment[1]
Largemouth Bass	*Micropterus salmoides*	✦✕✓	✦
Least Darter	*Etheostoma microperca*	✦	
Logperch	*Percina caprodes*	✦✓	✦
Longear Sunfish	*Lepomis megalotis*	✦✓	✦
Longnose Dace	*Rhinichthys cataractae*	✕✓	
Mimic Shiner	*Notropis volucellus*	✦✓	✦
Northern Hogsucker	*Hypentelium nigricans*	✦✕✓	
Northern Pike	*Esox lucius*	✦✕✓	✦
Northern Redbelly Dace	*Phoxinus eos*	✕	✦
Pumpkinseed	*Lepomis gibbosus*	✦✕✓	✦
Rainbow Darter	*Etheostoma caeruleum*	✦✓	
Rainbow Trout	*Oncorhynchus mykiss*	✦✓	✦
River Chub	*Nocomis micropogon*	✓	
Rock Bass	*Ambloplites rupestris*	✦✕✓	✦
Rosyface Shiner	*Notropis rubellus*	✦✕✓	
Round Goby	*Neogobius melanostomus*	✦✓	✦
Sand Shiner	*Notropis stramineus*	✓	✦
Smallmouth Bass	*Micropterus dolomieu*	✦✕✓	✦
Spotfin Shiner	*Cyprinella spiloptera*	✦✓	✦
Spottail Shiner	*Notropis hudsonius*	✦✓	✦
Stonecat	*Noturus flavus*	✓	
Striped Shiner	*Luxilus chrysocephalus*	✦✓	
Walleye	*Sander vitreus*	✦	
White Sucker	*Catostomus commersonii*	✦✕✓	✦
YellowBullhead	*Ameiurus natalis*	✓	
Yellow Perch	*Perca flavescens*	✦✕✓	✦

[1] Sources: ✕Lake Simcoe Region Conservation Authority historical records 1979-2003 (Greenland International 2005)
✦DFO standardized sampling 2005/2006 (Marson and Mandrak 2009)
✓non-standardized sampling 2005 (Marson and Mandrak 2009)

REFERENCES

Greenland International Consulting Ltd. 2005. Site condition report for assessing round goby removal and eradication options for Pefferlaw Brook. Draft Report. 57 p.

Marson, D. and Mandrak, N.E. 2009. Changes in fish assemblages in Pefferlaw Brook following rotenone treatment, 2005-2006. Can. MS. Fish. Aquat. Sci.

APPENDIX 3: CHECKLIST OF STEPS IN DEVELOPING A RAPID RESPONSE PLAN

(Locke and Hanson 2009)

A. Before the Invasion

General preparation

- Understand all relevant laws, regulations, policies and guidelines that may affect the ability to undertake a rapid response.
- Identify who is responsible overall, and for each step in the rapid response.
- Identify a primary point of contact at each local, provincial, and federal agency involved, and at major stakeholder organizations as appropriate.
- Identify the source of funding.
- Identify existing frameworks, networks, etc., that may be useful in developing or implementing a rapid response plan.
- Develop a communication structure.

Detection

- Develop criteria for listing "species of concern".
- Develop a list of "species of concern".
- Make provision for dealing with "species of concern".
- Make provision for dealing with species not on the list.
  - Develop monitoring networks;
  - Develop monitoring network coordination.
- Develop a monitoring protocol.
- If necessary, conduct ecological inventories to establish baseline information on native and AIS populations.
- Develop protocols for identification of invaders.
- Develop a database of regional AIS sightings and established AIS populations.
- Communications:
  - List the stakeholders and agencies that should be notified in the event of detection.
  - Develop educational materials.
  - Develop a dedicated website and a toll-free telephone number to report sightings or access information on invasions.
  - Prepare generic press release statements.

Demarkation

- Identify who will conduct biological surveys for various environments/species, and collect data for risk assessment.
- Determine the likely composition of potential scientific assessment committees for various kinds of AIS.
- Communications: Develop a strategy for stakeholder consultation and communication of information.

Containment

- Develop criteria for determining the need for containment or restriction of use of an infested waterbody.
- Evaluate legal authority that will allow containment or restriction of use of the waterbody.
- Identify who is responsible for the enforcement of restrictions of specific systems, what enforcement resources may be required, and how to obtain additional resources or funding if needed.
- Communications: Identify the communications needs associated with containment or restriction of use.

Risk Assessment

- Identify who will conduct the risk assessment.
- Identify the information needs for risk assessment, develop the required protocols, ensure appropriate equipment and personnel will be available, and provide training to personnel.
- Identify control options for "species of concern".
- Formalize the decision support system for risk assessment and provide training.

Implementation

- Identify who is responsible for implementation of the rapid response.
- Develop protocols for the control methods that may be used.
- Provide training to rapid response group members with simulations and field trials.
- Communications: Identify the communications needs associated with implementation.

Follow-up

- Identify who is responsible for post-treatment monitoring.
- Identify protocols to be used in post-treatment monitoring to assess the effectiveness of the selected response.
- Identify protocols to evaluate the effectiveness of communication.

B. Post-invasion

Detection

- Report the suspected AIS.
- Confirm the identity of the specimen.
- Deposit voucher specimens at the appropriate permanent archive.
- Update the database and web pages.
- Mobilize the communications officer and scientific advisory team.

APPENDIX 3: CHECKLIST OF STEPS IN DEVELOPING A RAPID RESPONSE PLAN (CONT'D)

Demarkation

- Determine distribution of invader and other relevant data needed for risk assessment, including vectors and options for containment.
- Convene scientific assessment committee and review preliminary data.
- Continue communicating with stakeholders as new information becomes available.
- Begin stakeholder consultation to determine the need (or legal requirement) for management.

Containment

- Scientific advisory committee evaluates need for containment or restriction and continues to assess risk as more data become available.
- Communicate the decision. Commence containment or restriction of use of the infested water body or facility, if necessary.
- Continue stakeholder consultation.
- Monitor the infestation.

Risk Assessment

- Continue to assemble data on the affected area.
- Review the control options.
- Identify risks and benefits associated with various controls, including no control.
- Consult stakeholders.
- Select the preferred control option.
- Set schedule for implementation.
- Communicate the decision.

Implementation

- Begin experimental or full-scale management effort.

Evaluating effectiveness (follow-up)

- Monitor for long enough to ensure the response was effective.
- Determine if response is complete.
- Take measures to prevent reinvasion.
- Evaluate the effectiveness of communication.
- Debrief the process.

REFERENCES

Locke, A. and Hanson, J.M. 2009. Rapid response to non-indigenous species. 3. A proposed framework. Aquatic Invasions 4: 259-273.

APPENDIX 4: COMMUNICATION ACTIONS UNDERTAKEN IN EACH PHASE

Detection Phase
August 2004

- An intensive public awareness campaign was mounted by OMNR, OFAH, and local angling groups to inform the public of the urgency of the situation.
- An outreach campaign was initiated, including door to door canvassing of residents, marinas, tackle shops, and over 300 mail-outs to resorts, marinas, bait operators and licence issuers. Warning signs were posted at all public access and fishing areas.

Demarkation Phase
Winter 2004/2005

- Invasive Species Workshop was held at York University (November 7, 2004), various fishing shows.
- Mail-outs were sent to ice-hut operators.

Containment Phase
Spring/Summer 2005

- Information packages were sent to baitfish retailers and harvesters to ensure infestation is not spread or intensified.
- The Goby Fishing Derby (June 5, 2005) was held as a cooperative event among many partners.

Implementation Phase
October 2005

- Early October - Briefings were provided for targeted stakeholders and local political representatives before the public meeting in order to build support and endorsement. Some of these stakeholders would be at the public meeting and help gain support of public.
- A public meeting was held October 4, 2005.
- A media/information centre was maintained throughout the fish removal and treatment phases.
- A public awareness campaign was mounted including a media advisory, paid public notice, 2 news releases, display and fact sheets developed for the public meeting on the control option, fact sheets and brochures on invasive species were provided.

Follow-up Phase
Fall 2005-Summer 2006

- A public meeting was held June 28, 2006, hosted by OMNR, to update the public on the eradication project.